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U. S. ARMY INSTALLATION RESTORATION PROGRAM

RECORD OF DECISION

UMATILLA DEPOT ACTIVITY EXPLOSIVES WASHOUT LAGOONS SOILS OPERABLE UNIT

September 1992

Signed 9-30-92

In accordance with Army Regulation 200-2, this document is intended by the Army to comply with the National Environmental Policy Act of 1969 (NEPA).

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ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or relevant and appropriate requirements
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
cy	Cubic yards
DNB	1,3-Dinitrobenzene
2,4-DNT	2,4-Dinitrotoluene
2,6-DNT	2,6-Dinitrotoluene
DoD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
EPIC	Environmental Photographic Interpretation Center
FFA	Federal Facility Agreement
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (High Melting Explosive)
HRS	Hazard Ranking System
IRIS	Integrated Risk Information System
MAIV	Mechanically agitated in-vessel
N-Tetryl	2,4,6-Tetranitro-N-methylaniline
NA	Not applicable
NAAQS	National Ambient Air Quality Standards

NB	Nitrobenzene
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NPL	National Priorities List
O&M	Operations and maintenance
OAR	Oregon Administrative Rules
ODEQ	Oregon Department of Environmental Quality
ORNL	Oak Ridge National Laboratory
ppm	Parts per million (equivalent to μg/g and mg/kg)
RAC	Remedial action criteria
RCRA	Resource Conservation and Recovery Act
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine (Royal Demolition Explosive)
RfD	Reference dose
RI/FS	Remedial investigation and feasibility study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
TBC	To be considered
TCLP	Toxicity characteristic leaching procedure
TNB	1,3,5-Trinitrobenzene
TNT	2,4,6-Trinitrotoluene
TRC	Technical Review Committee
UMDA	U.S. Army Depot Activity at Umatilla
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency

SECTION 1

DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

U.S. Army Depot Activity, Umatilla
Explosives Washout Lagoons, Soils Operable Unit
Hermiston, Oregon 97838-9544

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the Explosives Washout Lagoons Soils Operable Unit at the U.S. Army Depot Activity, Umatilla (UMDA), in Hermiston, Oregon, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The decision is based on the administrative record for this site. Documents contained in the record are identified in Section 2.2.

The remedy was selected by the U.S. Army and the U.S. Environmental Protection Agency (EPA). The State of Oregon concurs with the selected remedy.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

This operable unit is the first of two that are planned for the Explosives Washout Lagoons. It addresses contaminated soils at the lagoons and is the final remedial action planned for those soils. The purpose of the soils operable unit is to reduce the risks associated with exposure to lagoon soils and thus address one of the principal threats at the site. The second operable unit will involve continued study and possible remediation of contaminated groundwater beneath the lagoons; this operable unit is being integrated with facility-wide groundwater issues.

The major components of the selected remedy include the following:

- Excavation of lagoon soils having 2,4,6-trinitrotoluene (TNT) or hexahydro-1,3,5-trinitro-1,3,5-triazine (commonly referred to as Royal Demolition Explosive or RDX) concentrations greater than 30 parts per million (ppm) each (initially estimated to be 6,800 tons of soil);

- Onsite biological treatment of excavated soils, via composting, to TNT and RDX concentrations of 30 ppm or less; and

- Replacement of composted soils in the excavation, covering the area with two feet of clean soil, and revegetating.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. This remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable, and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element.

This remedy is intended to provide sufficient remediation for the probable scenario of future industrial use. Because the remedy might not allow for unrestricted future use of the site, the five-year review will apply to this action. That review will include consideration of the following elements:

- Explosives concentrations measured following soil treatment, since actual concentrations might be sufficiently low to allow for unrestricted use

- The hazard index (HI) of 1,3,5-trinitrobenzene, as recalculated following chemical-specific toxicity studies recently initiated by the U.S. Army

- Continued integrity of the clean soil cover

LEAD AND SUPPORT AGENCY ACCEPTANCE OF THE RECORD OF DECISION, U.S. ARMY DEPOT ACTIVITY UMATILLA, EXPLOSIVES WASHOUT LAGOONS, SOILS OPERABLE UNIT

Signature sheet for the foregoing Record of Decision for the Explosives Washout Lagoons Soils Operable Unit final action at the U.S. Army Depot Activity at Umatilla between the U.S. Army and the United States Environmental Protection Agency, with concurrence by the State of Oregon Department of Environmental Quality.

Lewis D. Walker
Lewis D. Walker
Deputy Assistant Secretary of the Army
(Environment, Safety, and Occupational Health)

9/30/92
Date

LEAD AND SUPPORT AGENCY ACCEPTANCE OF THE RECORD OF DECISION, U.S. ARMY DEPOT ACTIVITY UMATILLA, EXPLOSIVES WASHOUT LAGOONS, SOILS OPERABLE UNIT (CONT.)

Signature sheet for the foregoing Record of Decision for the Explosives Washout Lagoons Soils Operable Unit final action at the U.S. Army Depot Activity at Umatilla between the U.S. Army and the United States Environmental Protection Agency, with concurrence by the State of Oregon Department of Environmental Quality.

William D McCune Jr   24 Sep 92

Lieutenant Colonel William D. McCune   Date
Commander, U.S. Army Depot Activity, Umatilla

LEAD AND SUPPORT AGENCY ACCEPTANCE
OF THE RECORD OF DECISION,
U.S. ARMY DEPOT ACTIVITY UMATILLA,
EXPLOSIVES WASHOUT LAGOONS, SOILS OPERABLE UNIT (CONT.)

Signature sheet for the foregoing Record of Decision for the Explosives Washout Lagoons Soils Operable Unit final action at the U.S. Army Depot Activity at Umatilla between the U.S. Army and the United States Environmental Protection Agency, with concurrence by the State of Oregon Department of Environmental Quality.

for Gerald Emison
Dana A. Rasmussen
Regional Administrator, Region 10
U.S. Environmental Protection Agency

9-25-92
Date

LEAD AND SUPPORT AGENCY ACCEPTANCE
OF THE RECORD OF DECISION,
U.S. ARMY DEPOT ACTIVITY UMATILLA,
EXPLOSIVES WASHOUT LAGOONS, SOILS OPERABLE UNIT (CONT.)

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Fred Hansen — 9/30/92

Frederic J. Hansen — Date
Oregon Department of Environmental Quality

Note: The State of Oregon's Letter of Concurrence is appended to this Record of Decision.

SECTION 2

DECISION SUMMARY

This Decision Summary provides an overview of the problems posed by the conditions at the UMDA Explosives Washout Lagoons, the remedial alternatives, and the analysis of those options. Following that, it explains the rationale for the remedy selection and describes how the selected remedy satisfies statutory requirements.

2.1 SITE NAME, LOCATION, AND DESCRIPTION

The U.S. Army Depot Activity at Umatilla is located in northeastern Oregon in Morrow and Umatilla Counties, approximately 5 miles west of Hermiston, Oregon, as shown in Figure 1. The installation covers about 19,700 acres of land. The UMDA Explosives Washout Lagoons (Site 4) are located in Coyote Coulee, a linear depression in the center of the UMDA installation, as shown in Figure 2.

The Explosives Washout Lagoons are two adjacent, unlined, rectangular lagoons constructed in the native sandy-gravelly soil. The north and south lagoons measure 80 feet by 39 feet and 80 feet by 27 feet, respectively, and both are 6 feet deep. A 15-foot-wide gravel berm separates the lagoons, and gravel berms encircle both. The depth from the bottom of the lagoons to groundwater generally varies from 45 to 50 feet. The lagoons are typically dry; any collected precipitation tends to infiltrate rapidly. There is virtually no vegetation in the lagoons or along the berms.

UMDA was established as an Army ordnance depot in 1941 for the purpose of storing and handling munitions. Access is currently restricted to military personnel and authorized contractors. However, the ordnance storage mission at UMDA has been transferred to another installation, and UMDA is scheduled for future realignment under the Department of Defense (DoD) Base Realignment and Closure (BRAC) program. Under this program, it is probable that the Army will eventually vacate the site; ownership could then be relinquished to another governmental agency or private interests. Light industry is considered to be the most likely future land use scenario; future residential use is also a possibility.

Northeastern Oregon, the setting for UMDA, is characterized by a semi-arid, cold desert climate, an average annual precipitation of 8 to 9 inches, and a potential evapotranspiration rate of 32 inches. The installation is located on a regional plateau of low relief that consists of relatively permeable glaciofluvial sand and gravel overlying Columbia River Basalt.

Groundwater occurs primarily in two settings: in an unconfined aquifer within the overlying deposits and weathered basalts, and in a vertical sequence of semi-confined and

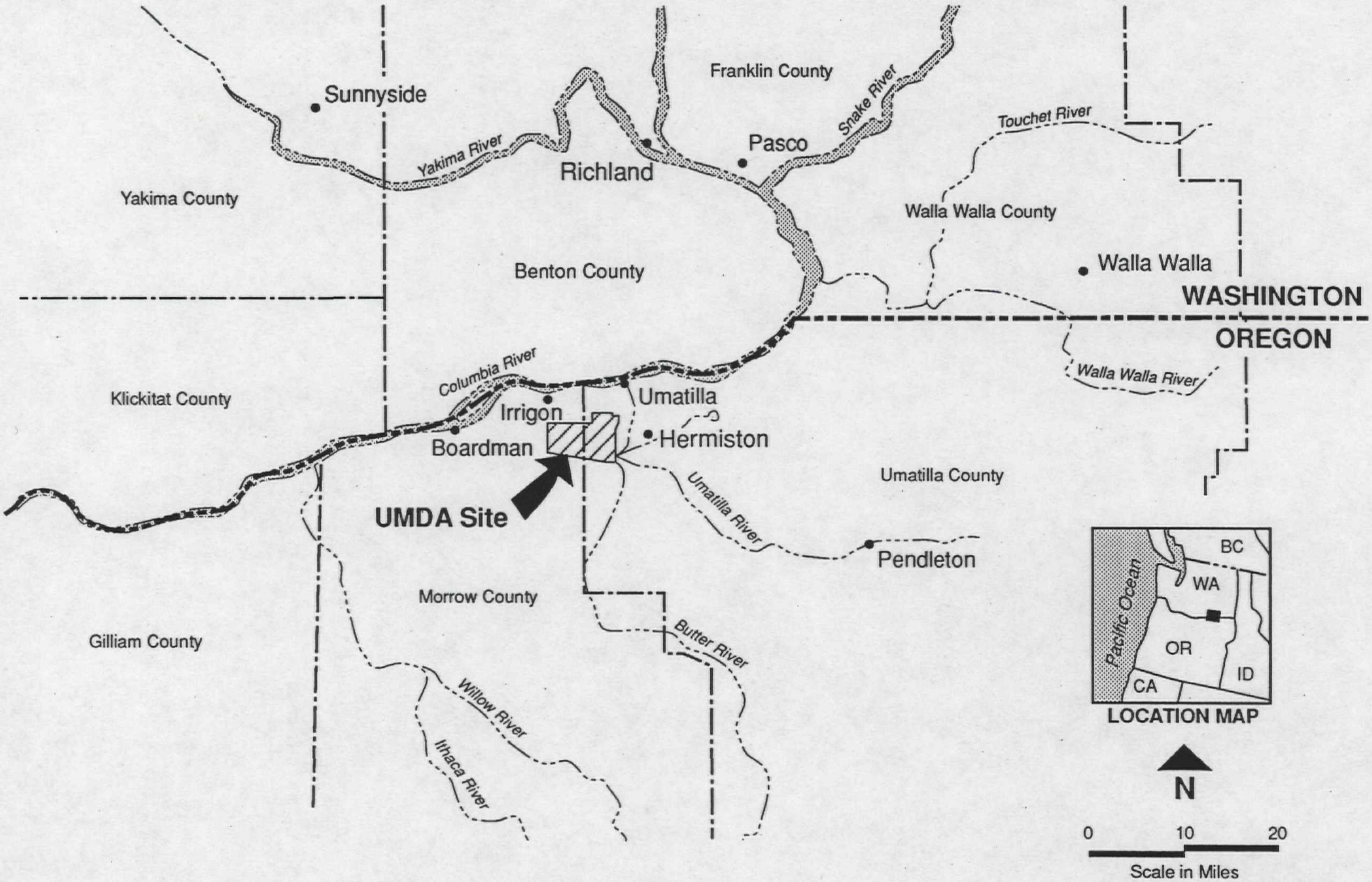
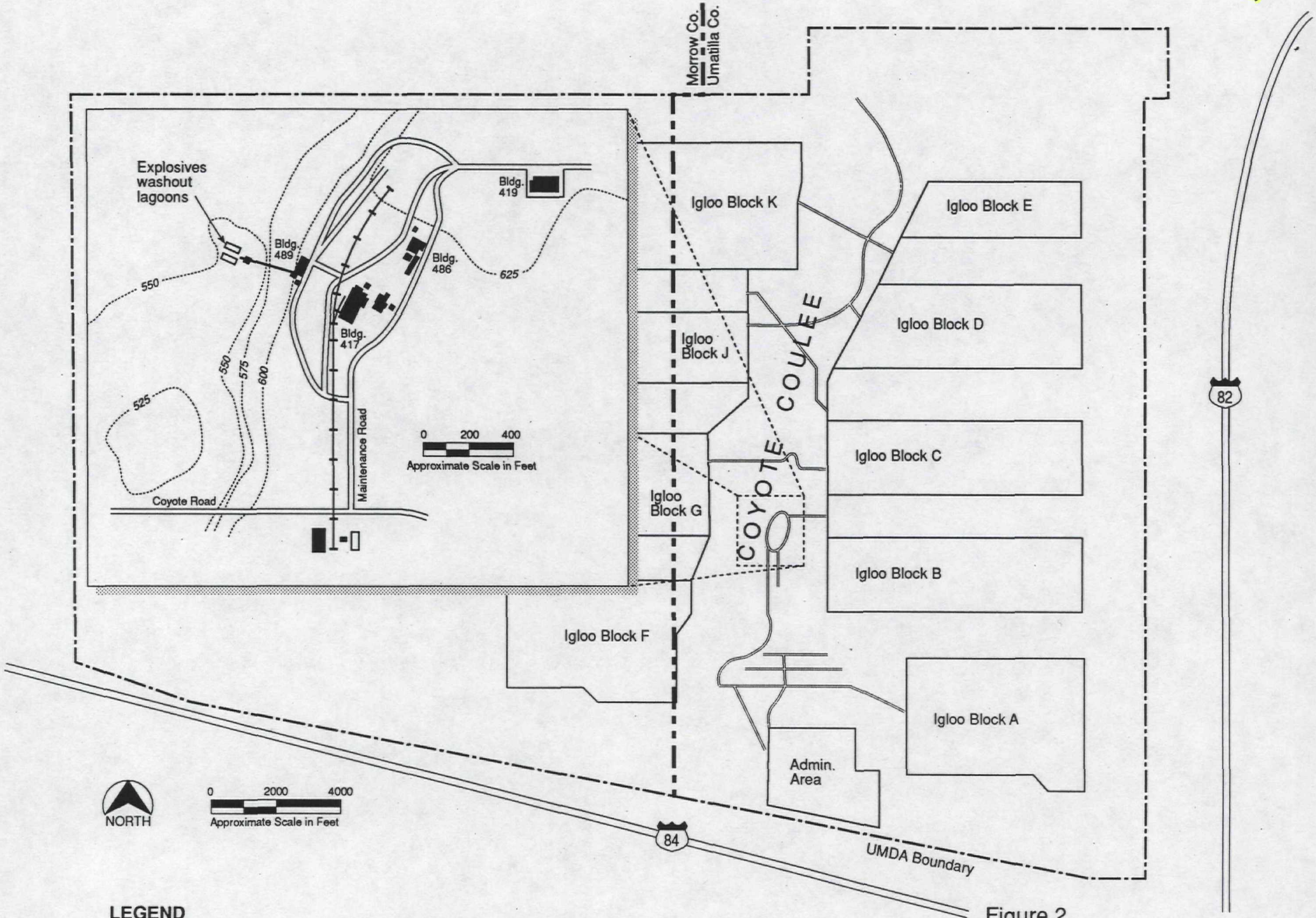


Figure 1
Facility Location Map
Umatilla Depot Activity



LEGEND

525 Surface elevations

Figure 2

Location of Explosives Washout Lagoons

confined aquifers within the basalt. Groundwater flows trend to the north and northwest. However, regional flow gradients in the uppermost aquifer are influenced by irrigation, pumping, and leakage from irrigation canals. The Columbia River flows from east to west approximately 3 miles to the north of the UMDA boundary, and the Umatilla River flows from south to north approximately 1 to 2 miles to the east. No natural streams occur within UMDA; the facility is characterized by areas of closed drainage.

The region surrounding UMDA is primarily used for irrigated agriculture. The population centers closest to UMDA are Hermiston (population 10,075), approximately 5 miles east; Umatilla (population 3,032), approximately 3 miles northeast; and Irrigon (population 820), 2 miles northwest. The total populations of Umatilla and Morrow Counties are approximately 59,000 and 7,650, respectively.

Approximately 1,470 wells have been identified within a 4-mile radius of UMDA, the majority of which are used for domestic and irrigation water. Three municipal water systems (Hermiston, Umatilla, and Irrigon) draw from groundwater within a 4-mile radius of UMDA. The Columbia River is a major source of potable and irrigation water, and is also used for recreation, fishing, and the generation of hydroelectric power. The principal use of the Umatilla River is irrigation.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

From the 1950s until 1965, UMDA operated an onsite explosives washout plant similar to that at other Army installations. The plant processed munitions to remove and recover explosives using a pressurized hot water system. The principal explosives consisted of the following:

- 2,4,6-Trinitrotoluene (TNT)
- Hexahydro-1,3,5-trinitro-1,3,5-triazine (commonly referred to as Royal Demolition Explosive or RDX)
- Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (commonly referred to as High Melting Explosive or HMX)
- 2,4,6-Tetranitro-N-methylaniline (N-Tetryl)

In addition, the munitions contained small quantities of 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,6-DNT), 1,3,5-trinitrobenzene (TNB), 1,3-dinitrobenzene (DNB), and nitrobenzene (NB), occurring as either impurities or degradation products of TNT.

Operation of the plant included flushing and draining the explosives washout system. The washwater produced was discharged via an open metal trough to the two infiltration lagoons located to the northwest of the plant. The lagoons were constructed in the 1950s and used until 1965, when plant operations and all discharges to the lagoons ended. A total of 85,000,000 gallons of effluent is estimated to have been discharged to the lagoons during the period of plant operation.

An initial installation assessment was performed in 1978 and 1979 to evaluate environmental quality at UMDA with regard to the past use, storage, treatment, and disposal of toxic and hazardous materials. Based on imagery analysis provided by EPA's Environmental Photographic Interpretation Center (EPIC) as part of the assessment, the Explosives Washout Lagoons (Site 4) were characterized as a potentially hazardous site. In 1981, Battelle conducted an Environmental Contamination Survey and Assessment at UMDA and identified what appeared to be a 45-acre plume of RDX in the shallow aquifer underneath the Explosives Washout Lagoons. Battelle concluded that discharges to the lagoons had caused contamination of the alluvial aquifer. Subsequent investigations confirmed the presence of explosives in the soil and groundwater.

In 1984, the Explosives Washout Lagoons were evaluated using EPA's Hazard Ranking System and received a score in excess of 28.5. As a result, the lagoons were proposed for inclusion on the National Priorities List (NPL) in 49 Fed. Reg. 40320 (October 15, 1984). They were formally listed on the NPL in 49 Fed. Reg. 27620 (July 22, 1987) based on the Hazard Ranking System (HRS) score and the results of the installation Resource Conservation and Recovery Act (RCRA) Facility Assessment.

On October 31, 1989, a Federal Facility Agreement (FFA) was executed by UMDA, the Army, EPA Region X, and the Oregon Department of Environmental Quality (ODEQ). The FFA identifies the Army as the lead agency for initiating response actions at UMDA. One of the purposes of the FFA was to establish a framework for developing and implementing appropriate response actions at UMDA in accordance with CERCLA, the NCP, and Superfund guidance and policy. Remediation of contaminated soil and groundwater at the lagoons was a task identified within this framework. A remedial investigation and feasibility study (RI/FS) of the entire UMDA installation, including the lagoons, was initiated in 1990 to determine the nature and extent of contamination and to identify alternatives available to clean up the facility.

The following documents outline the results of the site investigations and assessments of cleanup actions for the Explosives Washout Lagoons:

1. *Risk Assessment for the Explosives Washout Lagoons (Site 4), Umatilla Depot Activity, Hermiston, Oregon.* Prepared by Dames & Moore for the U.S. Army Toxic and Hazardous Materials Agency. 1992.

2. *Explosives Washout Lagoons Soils Operable Unit Supplemental Investigation, Technical and Environmental Management Support of Installation Restoration Technology Development Program*, Umatilla Depot Activity, Hermiston, Oregon. Prepared by Morrison Knudsen Environmental Services/CH2M HILL for the U.S. Army Toxic and Hazardous Materials Agency. 1992.

3. *Feasibility Study for the Explosives Washout Lagoons (Site 4) Soils Operable Unit, Umatilla Depot Activity, Hermiston, Oregon.* Prepared by CH2M HILL/Morrison Knudsen Environmental Services for the U.S. Army Toxic and Hazardous Materials Agency. 1992.

4. *Optimization of Composting for Explosives Contaminated Soil.* Prepared by Roy F. Weston for the U.S. Army Toxic and Hazardous Materials Agency. 1991.

5. Arthur D. Little, Inc. *Testing to Determine Relationship Between Explosive Contaminated Sludge Components and Reactivity.* Prepared for the U.S. Army Toxic and Hazardous Materials Agency. Report No. AMXTH-TE-CR-86096. January 1987.

6. Oak Ridge National Laboratory (ORNL). *Characterization of Explosives Processing Decomposition Due to Composting.* Phase II Final Report. ORNL/TM-12029. Prepared under DOE Interagency Agreement No. 1016-B123-A1. November 1991.

2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

In 1988, the UMDA command assembled a Technical Review Committee (TRC) composed of elected and appointed officials and other interested citizens from the surrounding communities. Quarterly meetings provide an opportunity for UMDA to brief the TRC on installation environmental restoration projects and to solicit input from the TRC. Two TRC meetings were held during preparation of the supplemental investigation and feasibility study for the Explosives Washout Lagoons Soils Operable Unit. In those meetings, the TRC was informed as to the scope and methodology of the lagoon soils investigation and remediation.

The Feasibility Study and Proposed Plan for the Explosives Washout Lagoons Soils Operable Unit were released to the public on April 27, 1992. The public comment period started on that date and ended on May 27, 1992. The documents constituting the administrative record were made available to the public at the following locations: UMDA Building 1, Hermiston, Oregon; the Hermiston Public Library, Hermiston, Oregon; and the EPA offices in Portland, Oregon. The notice of availability of the Proposed Plan was published in the *Hermiston Herald*, the *Tri-City Herald*, and the *East Oregonian* in April 1992.

A public meeting was held at Armand Larive Junior High School, Hermiston, Oregon, on May 5, 1992, to inform the public of the preferred alternative and to seek public comments. At this meeting, representatives from UMDA, the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), EPA, ODEQ, and CH2M HILL (an environmental consultant) answered questions about the site and remedial alternatives under consideration. A response to comments received during this period is included in the Responsiveness Summary appended to this ROD.

2.4 SCOPE AND ROLE OF OPERABLE UNIT

Operable units are discrete actions that constitute incremental steps toward the final overall remedy. Operable units can be actions that completely address a geographic portion of a site or a specific problem, or can be one of many actions that will be taken at the site.

The Explosives Washout Lagoons site was divided into two operable units, soils and groundwater, to facilitate early remediation of the soil. The threats described in this ROD are those associated with the contaminated soil present at the lagoons. The Soils Operable Unit cleanup strategy presented here is considered a final action only for that soil.

Future groundwater usage is not assumed or addressed in this ROD, since this remedy is intended to address exposure to soil. UMDA groundwater, including groundwater associated with the Explosives Washout Lagoons, is being investigated on an installation-wide basis. The final remedial actions for the groundwater and for remaining portions of the UMDA installation will be proposed following completion of ongoing investigations.

2.5 SITE CHARACTERISTICS

The original source of contamination at the UMDA Explosives Washout Lagoons was the washwater discharge from washout plant operations. No other contamination sources are suspected. The type of contamination is explosive compounds, primarily TNT and RDX.

Several soil and groundwater investigations have been conducted at the Explosives Washout Lagoons from 1981 to the present. Samples collected from soil borings drilled beneath and surrounding the lagoons have been used to determine the vertical and horizontal extent of soil contamination. A network of 34 groundwater monitoring wells has been used to identify and map groundwater contamination. The investigation results are summarized as follows:

- **The contaminants most frequently detected in the soil are TNT, RDX, HMX, TNB, and 2,4-DNT.** Tetryl, 2,6-DNT, DNB, and NB are rarely if ever detected, and then only at low (less than 5 ppm) concentrations. No additional organic compounds were detected, and inorganic compound concentrations were comparable to regional background concentrations.

- **Total explosives concentrations are well below the 12 percent minimum required for explosive reactivity.** Therefore, the soil is neither a RCRA characteristic waste for reactivity, nor is it sufficiently similar to RCRA explosives-derived listed wastes, which are listed solely for the characteristic of explosive reactivity.

- **Soil concentrations of NB and 2,4-DNT (when detected at all) are sufficiently low that leachate concentrations would not be expected to exceed Toxicity Characteristic Leaching Procedure (TCLP) levels.** NB and 2,4-DNT are the only explosives contaminants on the TCLP list. Therefore, the soil is not a RCRA characteristic waste for toxicity.

- **Contamination extends vertically from the soil surface to the water table (45 to 50 feet below the lagoons).** TNT and RDX concentrations typically range from 100 ppm to 2,000 ppm from the surface to a depth of 3.5 feet; they are generally less than 30 ppm below that. TNT concentrations exceeding 2,000 ppm have been observed in the top inch of soil, with a maximum of 88,000 ppm detected. HMX concentrations generally range from below detection (<1 ppm) to 100 ppm throughout the soil column. TNB concentrations generally vary from 2 ppm to 47 ppm throughout the soil column. 2,4-DNT is typically not detected in the upper 6 feet of soil; concentrations are relatively low throughout the remainder of the soil column (below detection [<1 ppm] to 5 ppm).

- **Contamination does not extend laterally beyond the berms surrounding the lagoons,** except at the interface between the unsaturated soil and the groundwater.

- **TNT and RDX concentrations up to 5,500 ppm are observed in the central berm dividing the two lagoons.** Explosives concentrations measured in the perimeter berms are less than 20 ppm.

Vertical concentration profiles for TNT and RDX are shown in Figures 3 and 4. These profiles are based on four sampling boreholes installed in 1991. The total volume of soil contaminated with detectable levels of one or more explosives is approximately 30,000 cubic yards (cy).

FIGURE 3

TNT CONTAMINATION

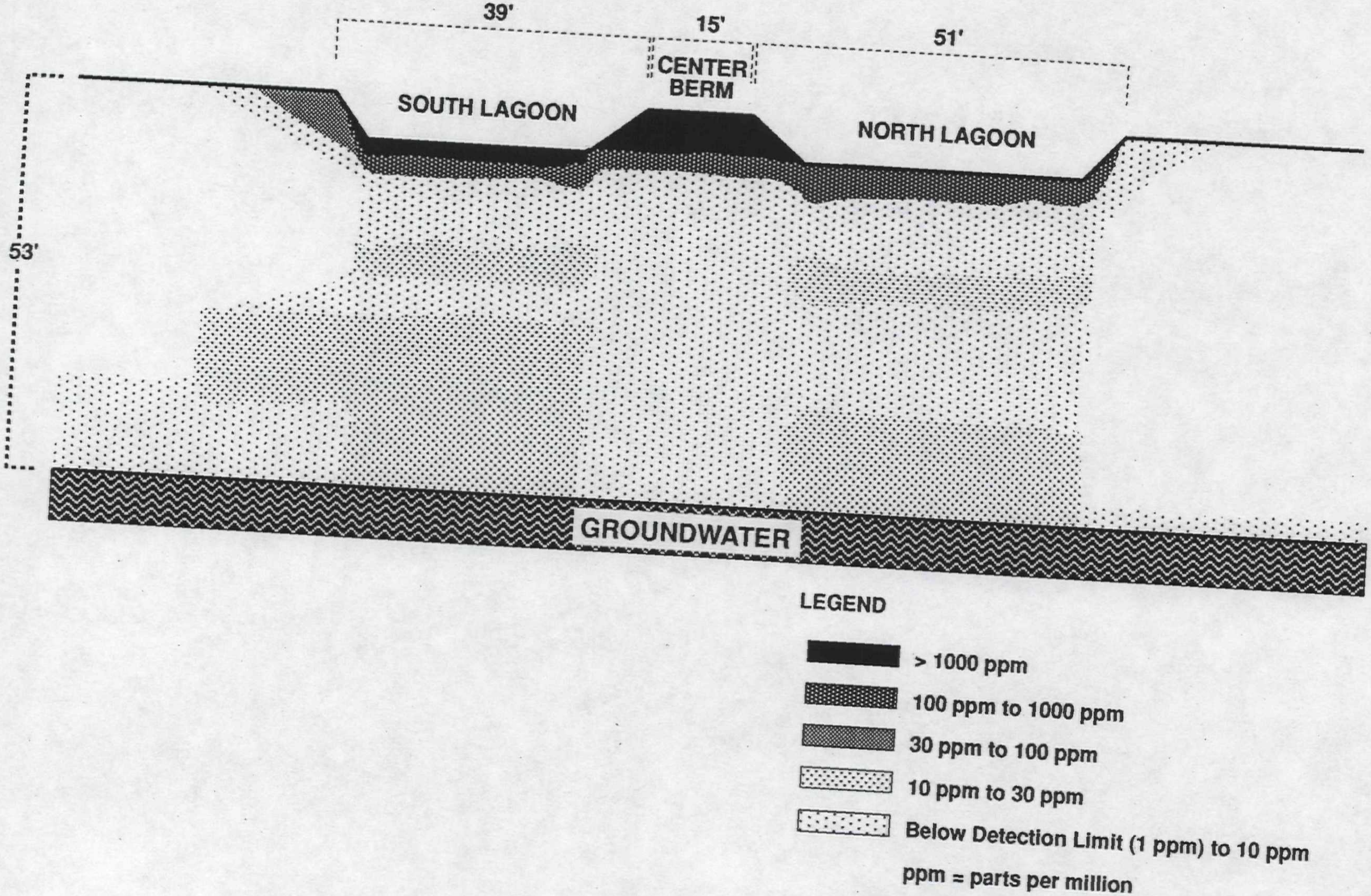
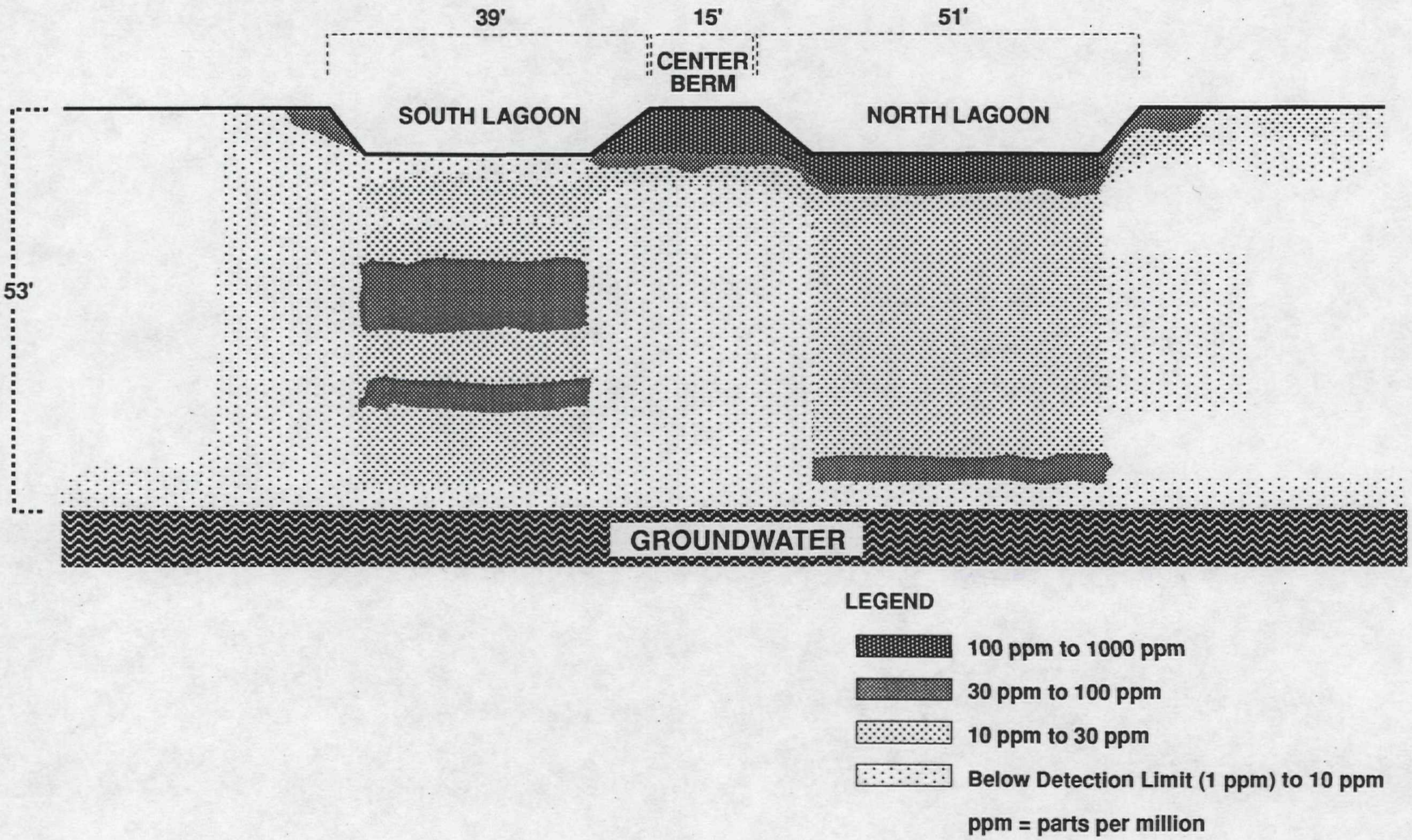


FIGURE 4

RDX CONTAMINATION



Physical and chemical properties of the explosives are provided in Table 1. In general, the explosives can be characterized as having relatively low aqueous solubility and low volatility. Health effects criteria for the explosives, including carcinogenic data from EPA databases, are presented in Section 2.6.

Potential routes for migration of the explosives include the following:

- **Air:** Airborne transport of soil contaminants might occur via the dispersion of soil particles, particularly if soil-disturbing activities are performed at the lagoons. Passive transport of soil contaminants is unlikely given the low volatility of the explosives.

- **Surface water:** There is little potential for surface water transport of the explosives. The lagoons are not located within a floodplain, there is virtually no run-on to or run-off from the lagoons due to the raised berms, and there are no natural or man-made drainage systems in the area of the lagoons. The low precipitation rate and high soil permeability allow for ready percolation of any rain falling directly onto the lagoons.

- **Subsurface:** Infiltration of precipitation provides a potential subsurface pathway for migration. However, the rate of transport is expected to be low due to the low precipitation and high evaporation rates in the region.

2.6 SUMMARY OF SITE RISKS

This section summarizes the human health risks and environmental impacts associated with exposure to site contaminants and provides potential remedial action criteria.

2.6.1 Human Health Risks

A baseline risk assessment was conducted by the Army to estimate the risk posed to human health by the Explosives Washout Lagoons should they remain in their current state with no remediation. The risk assessment consisted of an exposure assessment, toxicity assessment, and human health risk characterization. The exposure assessment detailed the exposure pathways (such as dust inhalation) that exist at the site for various receptors. The toxicity assessment documented the adverse effects that can be caused in a receptor as a result of exposure to a site contaminant.

The health risk evaluation used both the exposure concentrations and the toxicity data to determine an HI for potential noncarcinogenic effects and a cancer risk level for potential carcinogenic contaminants. In general, an HI of less than or equal to 1 indicates that even the most sensitive population is not likely to experience adverse

Table 1
Physical and Chemical Properties of the Explosives

	TNT	2,4-DNT	2,6-DNT	TNB	DNB	RDX	HMX	Tetryl
CAS Registry No.	118-96-7	121-14-2	606-20-2	99-35-4	99-65-0	121-82-4	2691-41-0	479-45-8
Empirical Formula	$C_7H_5N_3O_6$	$C_7H_6N_2O_4$	$C_7H_6N_2O_4$	$C_6H_3N_3O_6$	$C_6H_4N_2O_4$	$C_3H_6N_6O_6$	$C_4H_8N_8O_8$	$C_7H_5N_5O_8$
Molecular Weight	227.15	182.15	182.15	213.12	168.12	222.15	296.20	287.17
Density (g/cm^3)	1.65	1.521	1.538	1.63	1.575	1.83	1.90(β form)	1.73
Melting Point (°C)	80.75	72	66	122	90	205	286	129.5
Vapor Pressure (mm Hg, 25°C)	5.51×10^{-6}	2.17×10^{-4}	5.67×10^{-4}	3.03×10^{-6}	1.31×10^{-4}	4.03×10^{-9}	3.33×10^{-14}	5.69×10^{-9}
Aqueous Solubility (mg/L, 25°C)	150	280	206	385	533	60	5	80
Henry's Constant (atm.m^3/mole, 25°C)	1.10×10^{-8}	1.86×10^{-7}	4.86×10^{-7}	2.21×10^{-9}	5.44×10^{-8}	1.96×10^{-11}	2.60×10^{-15}	2.69×10^{-11}
Log K_{ow}	2.00	1.98	1.89	1.18	1.49	0.87	0.26	1.65
K (ml/g)	1.00	0.68	0.21	2.23	0.45	0.21	0.44	0.71
R	4.46	3.34	1.72	8.72	2.55	1.73	2.51	3.46
Bio-concentration factor (BCF) (fish)	8.95	10.6	9.82	2.65	4.70	1.50	0.49	6.31

health effects. If it is above 1, there might be a concern for adverse health effects. The degree of concern typically correlates with the magnitude of the index if it is above 1. The cancer risk level is the additional chance that an exposed individual will develop cancer over the course of a lifetime. It is expressed as a probability such as 1×10^{-6} (one in one million).

Risk assessments involve calculations based on a number of factors, some of which are uncertain. First, the health effects criteria of specific chemicals are often based on limited laboratory studies on animal species which are then extrapolated to humans. Further, the exposure scenario requires estimation of the duration and frequency of exposure, the identity of the exposed individual, and the contaminant concentration at the point of exposure. If the value of a factor required for the risk assessment is uncertain, a conservative estimate is used so that a health-based exposure level or concentration can be calculated. For example, in order to calculate a reference dose for humans, toxicity assessments divide doses observed to cause health effects in animals by an uncertainty factor to account for species differences and human population variability. The uncertainty factors for the explosives of concern are given in Table 2. In the case of uncertainties associated with exposure scenarios, the most conservative plausible scenario is selected. For example, in the Explosives Washout Lagoons risk assessment, since it is possible that the site might be used for residential purposes, risk values were calculated for a residential-use scenario.

Contaminants of concern in the UMDA Explosives Washout Lagoons Soil Operable Unit were identified as those explosives detected in soil samples collected during the lagoon investigations. They were:

- TNB
- DNB
- TNT
- 2,4-DNT
- HMX
- NB
- RDX

The populations at risk of exposure to these explosives were identified by considering both current and future use scenarios. Currently, public access to the UMDA facility is restricted, and there is little incentive or opportunity for trespassers to approach the lagoon area, so public exposure is unlikely. There are no operations being conducted in the lagoon area other than remediation, so unplanned exposure of military personnel is also unlikely. Therefore, the potential for current exposure was judged to be low and risks associated with current exposure scenarios were not evaluated.

The probability of future exposure to human receptors was considered high, since it is likely that DoD will eventually vacate UMDA. A light industrial land use scenario is

Table 2
Health Effects Criteria for Contaminants of Concern
Explosives Washout Lagoons (Site 4), UMDA

Contaminant of Concern	Slope Factor (mg/kg-day)-1	Source	Weight of Evidence Classification	Cancer Type	Reference Dose (mg/kg-day)	Source	Critical Effect	Uncertainty Factor	Confidence Level
1,3,5-Trinitrobenzene					5.00E-05	IRIS	Increased splenic weight	10,000	low
1,3-Dinitrobenzene					1.00E-04	IRIS	Increased splenic weight	3,000	low
2,4,6-Trinitrotoluene	0.030	IRIS	C	urinary bladder papillomas	5.00E-04	IRIS	Liver effects	1,000	medium
2,4-Dinitrotoluene	0.680	HEAST	B2	liver, mammary gland	6.00E-04	USEPA, 1991c	Hepatic alterations	1,000	low
2,6-Dinitrotoluene	0.680	HEAST	B2	(a)	1.00E-03	USEPA, 1991c	Liver, kidney, neurological, reproductive and hematological effects	3,000	low
HMX					5.00E-02	IRIS	Hepatic lesions	1,000	low
Nitrobenzene					5.00E-04	IRIS	Hematologic, adrenal, renal, and hepatic lesions	10,000	low
RDX	0.110	HEAST	C	hepatocellular carcinomas and adenomas	3.00E-03	IRIS	Inflammation of prostate	100	high
Tetryl					1.50E-03	Small, 1988	Skin sensitization	100	low

Sources: IRIS: Integrated Risk Information System, January 1991.
HEAST: Health Effects Assessment Summary Tables, 4th Quarter, September 1990.
EPA, 1991c: Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors
Small, 1988: Residual Explosives Criteria for Treatment of Area P Soil, Louisiana Army Ammunition Plant
(a) Based on potential carcinogenicity of 2,4-DNT.

considered the most probable scenario for future use of UMDA based on site topography and the availability of utilities and resources. The exposed population would consist of adult occupational workers. Future residential use is also possible, although it is not probable; because it is more conservative, it was also evaluated in the risk assessment.

The exposure pathways that were identified for each of these future use scenarios consist of the following:

- Incidental ingestion of soil
- Dust inhalation
- Dermal absorption of chemicals in soil
- Groundwater ingestion

The probability of significant exposures by other pathways was considered low. Only the first three pathways are applicable when evaluating risks associated with direct contact with contaminated soil. Risks associated with the ingestion of contaminated groundwater will be assessed in great detail during the study of the groundwater operable unit.

For purposes of calculating exposure, TNT, RDX, HMX, 1,3,5-TNB, and 2,4-DNT soil concentrations were conservatively assumed to be the maximum concentrations observed during the remedial investigation. Soil concentrations of the other explosives of concern were assumed to be the 95 percent upper confidence limit on the arithmetic mean of sampling data. Using these concentrations and exposure factors obtained from EPA's Risk Assessment Guidance for Superfund, chronic daily intake factors for each chemical within each exposure pathway for a given population at risk were calculated.

The basic toxicity information and health effects criteria for the explosives, including carcinogenic data from EPA databases and the models from which the risk values were derived, are presented in Table 2. All of the explosives are potentially toxic. In addition, both TNT and RDX are classified as potential human carcinogens (Group C), and 2,4-DNT is classified as a probable human carcinogen (Group B).

Because of the paucity of toxicity data for TNB, EPA derived a reference dose (RfD) by analogy to DNB. This analogy is considered appropriate and acceptable because of their structural similarity and the fact that TNB is less toxic on an acute basis than DNB. To account for the derivation by analogy, the RfD for TNB incorporates an additional uncertainty factor of 10. The Army has initiated TNB-specific toxicity studies designed to reduce this uncertainty and provide a more definitive estimate of the RfD.

Using the Table 2 data and the calculated chronic daily intake factors, excess cancer risks and noncancer HIs were calculated for each of the three direct soil contact pathways and two exposure scenarios, with the assumption that no remediation of soils takes place. The results are summarized in Table 3. Excess cancer risks are based on TNT, RDX, and 2,4-DNT. All chemicals of concern were evaluated for contribution to noncancer risk.

Table 3
Summary of Carcinogenic and Noncarcinogenic Risks
(Assuming No Remediation Occurs)[a]

Pathway	Residential Use		Light Industrial Use	
	Cancer Risks[b]	Noncancer Risks[c]	Cancer Risks[b]	Noncancer Risks[c]
Ingestion	1.77E-03	1120	3.33E-04	40.5
Inhalation	1.20E-05	0.66	4.9E-06	0.60
Dermal Contact	8.23E-03	3067	4.36E-03	546
Combined Pathways, Direct Contact with Soil Only	1.00E-02	4188	4.7E-03	587

[a]Concentrations used to calculate risks were derived from surface samples collected in the lagoons.
[b]Excess lifetime cancer risk to an individual.
[c]HI (an HI of 1.0 or lower generally indicates that no adverse effects would be expected).

If no soil remediation occurs, the excess cancer risks associated with direct soil contact assuming a reasonable maximum exposure scenario would be as follows:

- Residential, 1.00×10^{-2}
- Light Industrial, 4.70×10^{-3}

The noncancer HIs associated with direct soil contact assuming a reasonable maximum exposure scenario are as follows:

- Residential, 4188
- Light Industrial, 587

The NCP states that the acceptable risk range for carcinogens is 1×10^{-4} to 1×10^{-6} [40 CFR 300.430(e)(2)(i)(A)(2)]. For systemic toxicants (i.e., constituents having a noncancer health effect), the NCP states the following:

"For systemic toxicants, acceptable exposure levels shall represent concentration levels to which human populations, including sensitive subgroups, may be exposed without adverse effect during a lifetime or part of a lifetime, incorporating an adequate margin of safety" [40 CFR 300.430(e)(2)(i)(A)(1)].

As discussed earlier, acceptable exposure levels are usually evaluated in terms of the HI; an HI of less than or equal to 1 generally represents an acceptable exposure. However, the NCP further states that remedial action objectives must consider "(f)actors related to uncertainty" [40 CFR 300.430(e)(2)(i)(A)(4)]. Therefore, the calculated HIs must be considered within the context of the uncertainty factor, a conservatism that is built into the EPA-derived RfD. For example, if the uncertainty factor is several orders of magnitude greater than the calculated HI, an HI somewhat greater than one may be acceptable.

The potential risks associated with current soil contamination at the lagoons clearly exceed the acceptable carcinogenic risk range. In addition, the calculated HI exceeds 1 by two to three orders of magnitude, a level that is comparable to the uncertainty and therefore unacceptable. Therefore, in the event of likely future land use changes brought about by UMDA's inclusion in the BRAC program, actual or threatened releases of hazardous substances from the site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

2.6.2 Environmental Evaluation

An ecological assessment that includes the Explosives Washout Lagoons is underway as part of the installation-wide RI/FS. Results were not yet available, so qualitative observations and literature information were included in the feasibility study for the Explosives Washout Lagoons Soils Operable Unit. The lagoons and surrounding berms are devoid of vegetation, despite the fact that plant growth typical of the high desert climate is well-established in the area around the lagoons. In addition, explosives concentrations in surface soils at the lagoons exceed those levels determined in laboratory studies to cause marked stress to vegetation.

Although the UMDA installation is part of the critical winter range and habitat for several threatened and endangered avian species, none of these are directly affected by the Explosives Washout Lagoons, nor are they likely to be in the future.

2.6.3 Remedial Action Criteria

Neither state nor federal regulations contain chemical-specific soil cleanup standards for the contaminants of concern. However, both authorities provide a framework for developing risk-based remedial action criteria. The State of Oregon requires cleanup to background or, if that is not feasible, the lowest levels that are protective of human health and the environment and feasible. The NCP provides guidelines in terms of acceptable carcinogenic and non-carcinogenic risk. Therefore, the health criteria cited in Table 2, such as slope factors and reference doses, become "to-be-considered" (TBC) criteria for protectiveness and in evaluating compliance with applicable or relevant and appropriate requirements (ARARs).

Potential risk-based remedial action criteria (RAC) were calculated based on direct contact with lagoon soils. RAC for the contaminants of concern were developed to identify the soil concentrations equivalent to excess cancer risks of 1×10^{-6}, 1×10^{-5}, and 1×10^{-4}, and noncancer risks with HIs of 0.1, 1, and 10. The results are provided in Table 4.

2.7 DESCRIPTION OF ALTERNATIVES

A range of general response actions was considered for remediating the UMDA Explosives Washout Lagoons soil. The actions were first screened for general applicability, then several that appeared to be appropriate for the site were evaluated for effectiveness, implementability, and, to a lesser extent, cost. The actions evaluated included:

- No Action
- Institutional controls (monitoring)
- Containment (engineered cap, soil cover, vegetative cover, surface controls)
- Removal
- Immobilization (physical/chemical solidification and stabilization)
- Thermal treatment (via incineration)
- Biological treatment (via composting)
- Solvent extraction

From this evaluation, three potential remedial alternatives were assembled that contained one or more elements from the responses listed above. These alternatives are described in the following sections.

2.7.1 Alternative 1: No Action

Evaluation of the No Action alternative is required under CERCLA, serving as a common reference point against which other alternatives can be evaluated.

In Alternative 1, no containment, removal, or treatment of the soil at the Explosives Washout Lagoons would occur, and no new controls would be implemented to prevent human exposure. However, existing security provisions that limit public access continue until such time as the Army vacates the UMDA facility. Some natural chemical

Table 4
Summary of Risk-Based Remedial Action Criteria for Multiple Pathway Direct Contact Exposure for the Explosives Washout Lagoons (Site 4) for Residential and Light Industrial Land Use Scenarios

	Contaminant Concentrations (ppm) versus Excess Cancer Risk Levels					
	Residential Land Use Scenario			Industrial Land Use Scenario		
	1.00E-04	1.00E-05	1.00E-06	1.00E-04	1.00E-05	1.00E-06
Analyte						
1,3,5-TNB	--	--	--	--	--	--
1,3-DNB	--	--	--	--	--	--
2,4,6-TNT	396	40	4.0	837	84	8.4
2,4-DNT	17	1.7	0.17	37	3.7	0.37
HMX	--	--	--	--	--	--
NB	--	--	--	--	--	--
RDX	620	62	6.2	3,250	325	33

	Contaminant Concentrations (ppm) versus Hazard Indices					
	Residential Land Use Scenario			Industrial Land Use Scenario		
	HI = 0.1	HI = 1.0	HI = 10	HI = 0.1	HI = 1.0	HI = 10
Analyte						
1,3,5-TNB	0.10	0.96	9.6	0.67	6.7	67
1,3-DNB	0.19	1.9	19	1.3	13	133
2,4,6-TNT	0.95	9.5	95	6.7	67	667
2,4-DNT	1.1	11	114	8.0	80	800
HMX	95	946	9,458	667	6,669	66,687
NB	1.0	10	95	6.7	67	667
RDX	22	217	2,174	572	5,723	57,227

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or biological degradation of the explosives might occur, although the rate predicted based on site conditions will be very slow.

This alternative does not meet the Oregon requirement for cleanup to background, or the lowest levels that are protective and feasible, nor does it achieve protection of human health and the environment within the guidelines the NCP. The human health risks presented in Table 3 for future use scenarios are not reduced, and groundwater degradation can continue.

Alternative 1 requires no time to implement, and involves no capital or operations and maintenance (O&M) costs.

2.7.2 Alternative 2: Excavation, Incineration, and Onsite Disposal

Alternative 2 involves excavation of contaminated soils using conventional construction equipment, onsite incineration, and replacement of the treated soil in the lagoon excavation. A clean soil cover would be placed over the top, and the area would be graded and revegetated.

Within this alternative, three excavation options are considered:

- Excavation of all soil with detectable levels of explosives. The excavation will extend to the water table, and the soil volume will be 32,000 cy (47,000 tons). This option represents cleanup to background levels.
- Excavation of soils containing TNT or RDX concentrations greater than 30 ppm. The average excavation depth will be approximately 5 feet below the lagoons, and the soil volume will be about 4,800 cy (6,800 tons). This is a risk-based option representing removal of soils with an excess cancer risk of greater than 7×10^{-6} (industrial use scenario).
- Excavation to a depth of 20 feet below the lagoons. The soil volume will be 21,000 cy (30,000 tons). This is a non-risk-based option; it represents a conservative removal of all soil to which direct exposure during future soil-disturbing activities is likely. Because explosives concentrations are relatively consistent from 5 feet to the water table, no additional risk reduction is achieved.

A commercially-available mobile incinerator designed to process 4 tons per hour is assumed to be used for the 6,800-ton option, and a commercially-available transportable incinerator designed to process 20 tons per hour is assumed to be used for larger volume options.

In this alternative, it is expected that residual explosives concentrations in treated soil would be below detection levels (less than 1 ppm, with an excess total cancer risk of less than 1×10^{-6} and HIs of less than 1 for all explosives contaminants) and thus be protective of human health. This level of treatment has been demonstrated in full-scale remedial actions conducted at similar sites and would achieve the greatest reduction in contaminant concentrations of the all the alternatives. Assuming that residual concentrations below detection levels represent background, only this alternative can achieve a cleanup to background levels.

Suitable incineration units are available from several vendors. VESTA Technology, Inc., offers a 4-ton-per-hour unit, and IT Corporation, ENSCO Environmental Services, and Weston Services, Inc., among others, offer larger units. Rotary kiln incineration of explosives-contaminated soil has been approved by the Department of Defense Explosives Safety Board.

Some materials handling might be required for size reduction of larger rocks, but this effort is expected to be minimal. A treatment area would be developed in close proximity to the lagoons, with concrete and asphalt pads for the incinerator and feed staging operations. It is estimated that 1 year would be required to develop the site and prepare bid specifications for the incineration unit. A trial burn would be conducted to verify the destruction and removal efficiency for the explosives compounds and demonstrate performance of the air emissions controls. Baghouses would likely be required to control particulate emissions. Effluent streams from the incinerator would include gaseous emissions and treated soil and fly ash product. Treated soils and fly ash would be tested to verify that explosives concentrations met the cleanup criteria before replacement in the excavation. Actual incinerator operations would require from 3 to 7 months, depending on the soil volume and incinerator design.

The costs for Alternative 2 and the three excavation options would be as follows:

- Capital
    - 5-foot excavation: $650,000
    - 20-foot excavation: $1,200,000
    - Excavation to water table: $1,200,000
- O&M
    - 5-foot excavation: $3,800,000
    - 20-foot excavation: $7,092,000
    - Excavation to water table: $12,800,000

- Present Worth

  - 5-foot excavation: $4,120,000
  - 20-foot excavation: $7,650,000
  - Excavation to water table: $12,800,000

The following major ARARs are cited for Alternative 2:

- This alternative would comply with the process described in the Oregon Environmental Cleanup Law. Reducing explosives concentrations to essentially background levels is technically feasible using incineration; therefore, an excavation of all contaminated soils combined with incineration of the excavated soil is evaluated. Because the scope and cost of such a cleanup might be excessive, scenarios involving more limited excavations that are still protective and cost-effective are also evaluated.

- This alternative would comply with all state and National Ambient Air Quality Standards (NAAQS) air emissions ARARs for any remedial activities, such as excavation and incineration, that result in airborne discharges from the site.

- This alternative would comply with relevant and appropriate state solid waste guidelines for incineration units and replacement of incinerated soil in the excavation.

2.7.3 Alternative 3: Excavation, Composting, and Onsite Disposal

Alternative 3, the selected remedy, involves excavation of contaminated soils using conventional construction equipment, onsite composting, and replacement of the compost in the lagoon excavation. A clean soil cover will be placed over the top, and the area will be graded and revegetated.

Within this alternative, two excavation options are considered:

- Excavation of soils containing TNT or RDX concentrations greater than 30 ppm. The average excavation depth will be approximately 5 feet below the lagoons, and the soil volume will be about 4,800 cy (6,800 tons). This is a risk-based option representing removal of soils with an excess cancer risk of greater than 7×10^{-6} (industrial use scenario).

- Excavation to a depth of 20 feet below the lagoons. The soil volume will be 21,000 cy (30,000 tons). This is a non-risk-based option; it represents a conservative removal of all soil to which direct exposure during future soil-disturbing activities is likely. Because explosives concentrations are comparable at 5 feet and at 20 feet, no additional risk reduction is achieved.

An excavation of all contaminated soil (excavation to the water table), one of the options in Alternative 2, is not considered in Alternative 3. Composting technology cannot achieve background concentrations of explosives, and therefore it is not reasonable to combine treatment via composting with an excavation to the water table.

A facility designed to accept 100 cy of soil per week is assumed for the 6,800-ton option, while a facility designed to accept 200 cy per week is assumed for a volume of 30,000 tons.

In this alternative, it is expected that residual explosives concentrations will be reduced by 97 to 99 percent. The remedial action criteria are set at TNT and RDX concentrations of 30 ppm or less each. These levels correspond to an excess cancer risk under the industrial use scenario of 7×10^{-6} (assuming that 2,4-DNT is also present, at an average concentration of 1 ppm) and are within the range of acceptable cancer risks. The HIs for all explosives contaminants except TNB will be less than 1; the HI for TNB could be as high as 7, assuming no degradation of that explosive. This level of treatment has been demonstrated in site-specific pilot-scale treatability and optimization studies conducted at UMDA.

Composting is a well-known technology for the treatment of solid wastes, such as municipal wastewater treatment sludges and yard debris, whereby microbial populations degrade organic materials. Its application to explosives-contaminated soils is innovative. Composting requires conventional technology and can be readily implemented using commercially available equipment and materials.

Three different composting methods were evaluated for treating the lagoon soils: Mechanically-Agitated In-Vessel (MAIV) composting, static pile composting, and windrow composting. They differ in technical complexity and the degree to which they control temperature, moisture content, and aeration. Using MAIV composting, the soil is placed in a reactor vessel and agitated periodically. In static pile composting, the soil is composted in open piles without any mixing. With windrow composting, the soil is formed into elongated piles (windrows) that are turned regularly using a windrow machine. Site-specific studies have demonstrated that mixing, whether in an MAIV or in windrows, is more effective for reducing explosives concentrations than composting in static piles. Both MAIV and windrow composting are considered under this alternative.

The soil is mixed with suitable organic amendments to enhance biological activity prior to composting. Larger rocks might require screening and separate handling; they can be washed, and the washwater added to the compost mixture. The single effluent stream is the final compost. It will be tested to verify that explosives concentrations meet the remedial action criteria before replacement in the excavation. Approximately 1 year will be required to develop the site and prepare bid specifications for the composting facility. It is estimated that another year will be required to compost 6,800 tons of soil, and 2 years for 30,000 tons.

The costs for Alternative 3 (MAIV and windrow) and the two excavation volume options are as follows:

- Capital

  - 5-foot excavation (MAIV): $1,480,000
  - 20-foot excavation (MAIV): $2,314,000
  - 5-foot excavation (windrow): $880,000
  - 20-foot excavation (windrow): $1,784,000

- O&M

  - 5-foot excavation (MAIV): $1,783,000
  - 20-foot excavation (MAIV): $7,599,000
  - 5-foot excavation (windrow): $1,084,000
  - 20-foot excavation (windrow): $4,399,000

- Present Worth

  - 5-foot excavation (MAIV): $3,100,000
  - 20-foot excavation (MAIV): $8,200,000
  - 5-foot excavation (windrow): $1,870,000
  - 20-foot excavation (windrow): $5,590,000

The following major ARARs are cited for Alternative 3:

- This alternative complies with the process described in the Oregon Environmental Cleanup Law. Cleanup to background levels using composting is not technically feasible; such a cleanup can only be achieved under Alternative 2 using incineration. However, Alternative 3 does present a cleanup option that is protective and feasible.

- This alternative will meet relevant and appropriate state solid waste guidelines for compost units and management of the compost.

2.8 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

This section and Tables 5 and 6 summarize the relative performance of each of the three alternatives with respect to the nine CERLCA evaluation criteria.

2.8.1 Threshold Criteria

Overall protection of human health and the environment. Alternative 1, No Action, provides no protection for future users of the site or for the environment. Alternatives 2 and 3, Incineration and Composting, both provide overall protection of human health in accordance with the NCP.

First, both provide a clean soil cover, minimizing direct contact with underlying treated soils that might contain residual contaminants. In addition, both reduce the excess cancer risk in treated soils to within the range of 1×10^{-4} to 1×10^{-6} (industrial use scenario) and reduce concentrations of systemic toxicants to levels at which no adverse noncarcinogenic health effects would be expected, considering factors related to uncertainty. Alternative 2 is somewhat more protective than the selected remedy, Alternative 3. Alternative 2 reduces the excess cancer risk to less than 1×10^{-6} versus 7×10^{-6} for Alternative 3 (industrial use scenario). Alternative 2, Incineration, will reduce the noncarcinogenic HI in the treated soil to less than 1 for each explosive. Alternative 3, Composting, will reduce the HI of each explosive except TNB to less than 1. Under Alternative 3, the HI for TNB could be as high as 7, assuming that it is not degraded by composting. (By analogy to other explosives evaluated, substantial degradation of TNB is expected, but the extent has not been quantified.) However, the uncertainty factor for TNB is 10,000, three orders of magnitude greater than the HI. Considering this conservative uncertainty, no adverse noncarcinogenic health effects are expected in Alternative 3.

Alternatives 2 and 3 both reduce the plant stress associated with high concentrations of explosives. Residual contamination in the treated soil resulting in Alternative 3 could result in some minor growth retardation, although this will be minimized by the clean soil cover.

An excavation depth based on achieving TNT and RDX concentrations of 30 ppm each provides the best balance of net risk reduction and cost-effectiveness. There is a clear demarcation in the soil contamination profile (at a depth of about 5 feet) between concentrations of TNT and RDX greater and less than 30 ppm. Between 5 feet and the groundwater, TNT and RDX concentrations are consistently in the 10 to 30 ppm range. Therefore, an excavation between a depth of 5 feet and the groundwater does not result in additional risk reduction.

Achievement of ARARs. Alternative 1 does not comply with ARARs, whereas both Alternatives 2 and 3 comply with all ARARs.

Table 5
Comparative Evaluation of Alternatives

Effectiveness						
Overall Protection	**Compliance with ARARs**	**Long-Term Effectiveness**	**Reduction of Toxicity, Mobility, or Volume**	**Short-Term Effectiveness**	**Implementability**	**Total Cost**
Alternatives 2 and 3 provide overall protection of human health and the environment in accordance with the NCP by reducing the excess cancer risk to $<1 \times 10^{-6}$ and 7.2×10^{-6}, respectively (industrial use scenario), and noncancer risk to levels that are protective, taking into account factors related to uncertainty. Both alternatives significantly reduce plant stress associated with very high explosives concentrations; some minor reduction in growth height may still be observed in Alternative 3. Alternative 1 provides no protection for future users of the site, does not enhance protection of the environment, and is not addressed further in this table.	Alternatives 2 and 3 comply with all ARARs. In accordance with state requirements for remedial actions, the risk reduction benefits for variations on each alternative are shown as a function of cost.	Long-term effectiveness is achieved in Alternative 2 by the permanent destruction of 99.99 percent of contaminants. Alternative 3 achieves long-term protection by degrading contaminants by 97 to 99 percent.	Excavation to 5 feet below the lagoons reduces excess cancer risk by about 99.8 percent from initial levels. This increases to 99.9 percent at 20 feet and 100 percent at 47 feet. Both Alternatives 2 and 3 reduce contaminant concentrations in excavated soils, thereby reducing toxicity. Alternative 2 reduces toxicity by >99.99 percent. Alternative 3 reduces toxicity by 88 to 98 percent.	Both Alternatives 2 and 3 use appropriate controls to provide near-term protection of the public, onsite workers, and the environment during remedial activities. Alternative 2 could be implemented and completed within 15 to 19 months. Alternative 3 could be implemented and completed within 20 to 36 months.	Implementability of Alternative 2 has been demonstrated for similar contaminants at other sites. Alternative 3 is innovative, but supported by site-specific treatability studies. There appear to be no obstacles to obtaining necessary materials and agency approval.	Costs for a 47-foot excavation with treatment by incineration (Alternative 2) (cleanup-to-background) are \$14 million. For other excavation depths, Alternative 3 is less expensive, especially for low volume remediation (e.g., for a 5-foot excavation, costs are \$2 million for composting versus \$4 million for incineration.)

Table 6
Cost and Effectiveness of Alternatives as a Function of Excavation Depth

Alternative	Mass (tons)	Excess Cancer Risk Prior to Remediation[a]		Excess Cancer Risk Following Remediation[a]				Total Cost ($000)	Cost (present worth, $000)
				Excavated/Treated Soil		Soil Remaining Below Excavation Depth[d]			
		Industrial Use Scenario	Residential Use Scenario	Industrial Use Scenario	Residential Use Scenario	Industrial Use Scenario	Residential Use Scenario		
No Action	NA	4.7×10^{-3}	1.0×10^{-2}	NA	NA	4.7×10^{-3}	1.0×10^{-2}		0
Incineration									
2-foot excavation	3,700	4.7×10^{-3}	1.0×10^{-2}	$<1 \times 10^{-6}$	$<1 \times 10^{-6}$	8.0×10^{-5}	2.1×10^{-4}	2,730	2,540
5-foot excavation	6,800	4.7×10^{-3}	1.0×10^{-2}	$<1 \times 10^{-6}$	$<1 \times 10^{-6}$	7.2×10^{-6}	1.8×10^{-5}	4,470	4,120
20-foot excavation	30,000	4.7×10^{-3}	1.0×10^{-2}	$<1 \times 10^{-6}$	$<1 \times 10^{-6}$	7.2×10^{-6}	1.8×10^{-5}	8,290	7,650
47-foot excavation[b]	47,000	4.7×10^{-3}	1.0×10^{-2}	$<1 \times 10^{-6}$	$<1 \times 10^{-6}$	$<1 \times 10^{-6}$	$<1 \times 10^{-6}$	14,000	12,800
Composting—Windrows									
2-foot excavation	3,700	4.7×10^{-3}	1.0×10^{-2}	7.2×10^{-6}	1.8×10^{-5}	8.0×10^{-5}	2.1×10^{-4}	1,430	1,370
5-foot excavation	6,800	4.7×10^{-3}	1.0×10^{-2}	7.2×10^{-6}	1.8×10^{-5}	7.2×10^{-6}	1.8×10^{-5}	1,960	1,870
20-foot excavation	30,000	4.7×10^{-3}	1.0×10^{-2}	7.2×10^{-6}	1.8×10^{-5}	7.2×10^{-6}	1.8×10^{-5}	6,180	5,590
47-foot excavation[c]	NA	4.7×10^{-3}	1.0×10^{-2}	NA	NA	NA	NA	NA	NA
Composting—MAIV									
2-foot excavation	3,700	4.7×10^{-3}	1.0×10^{-2}	$<7.2 \times 10^{-6}$	$<1.8 \times 10^{-5}$	8.0×10^{-5}	2.1×10^{-4}	2,410	2,320
5-foot excavation	6,800	4.7×10^{-3}	1.0×10^{-2}	$<7.2 \times 10^{-6}$	$<1.8 \times 10^{-5}$	7.2×10^{-6}	1.8×10^{-5}	3,270	3,100
20-foot excavation	30,000	4.7×10^{-3}	1.0×10^{-2}	$<7.2 \times 10^{-6}$	$<1.8 \times 10^{-5}$	7.2×10^{-6}	1.8×10^{-5}	9,910	8,200
47-foot excavation[c]	NA	4.7×10^{-3}	1.0×10^{-2}	NA	NA	NA	NA	NA	NA

[a]Risk based on direct contact with soil: ingestion, inhalation, dermal contact.
[b]This scenario reflects cleanup to background. All contaminated soil would be treated.
[c]A combination of composting and a 47-foot excavation was not evaluated. The deep excavation is intended to reflect cleanup to background and cannot be achieved by composting.
[d]Risk calculations based on average TNT, RDX, and 2,4-DNT concentrations measured at indicated depth.
NA = Not applicable to this alternative.
cy = Cubic yards.

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There are no federal or state explosives-specific soil cleanup standards. In their absence, the most notable ARAR is the Oregon Environmental Cleanup Law. This law specifies a remediation process that requires cleanup to background levels or, if that is not feasible, cleanup to levels that are protective and feasible. Cleanup to background was evaluated in the feasibility study as an option under Alternative 2, whereby all soils with detectable levels of explosives would be incinerated to concentrations below detection limits. The selected remedy, Alternative 3, cannot reduce concentrations to below detection limits. Both Alternatives 2 and 3 were then evaluated in terms of achieving the lowest cleanup levels that would be protective and feasible. Health-based protective levels can be achieved under either alternative, but the selected remedy, Alternative 3, is significantly more cost-effective (i.e., "feasible" as defined by Oregon law).

2.8.2 Primary Balancing Criteria

Long-term effectiveness. In Alternative 1, No Action, there is virtually no long-term risk reduction and therefore the alternative does not demonstrate long-term effectiveness. The effectiveness of Alternative 2, Incineration, has been proven in full-scale remedial actions at sites with similar contamination. Incineration at those sites has resulted in the permanent destruction of 99.99 percent or greater of the explosives. The effectiveness of Alternative 3, Composting, has been demonstrated in site-specific pilot-scale treatability studies. In those studies, composting has degraded and immobilized 97 to greater than 99 percent of the explosives, and is therefore somewhat less effective than incineration.

Both Alternatives 2 and 3 result in treatment residuals, incinerated soil in Alternative 2 and composted soil in Alternative 3.

Reduction in toxicity, mobility, or volume of contaminants. Alternative 1 does not reduce the toxicity, mobility, and volume of contaminants. Both Alternatives 2 and 3 reduce the contaminant toxicity, mobility, and volume by a magnitude assumed to be comparable to the destruction of contaminants, or 99.99 percent. Alternative 3 reduces soil toxicity by 88 to 98 percent based in laboratory tests comparing the toxicity of contaminated soil and composted soil.

Short-term effectiveness. Alternative 1 is effective in the near-term, since public access to the UMDA installation is currently restricted and no military personnel are active in the vicinity of the Explosives Washout Lagoons. Both Alternatives 2 and 3 use appropriate controls to provide near-term protection of onsite workers, the public, and the environment during remedial activities.

Alternative 1 could be implemented immediately. Alternative 2 could be implemented and completed in 15 to 19 months. Alternative 3 could be implemented and completed in 24 to 36 months.

Implementability. There are substantial administrative obstacles to implementing Alternative 1, since this alternative does not meet state or EPA cleanup objectives.

Both Alternatives 2 and 3 can be readily implemented. A number of vendors are available for implementation of onsite incineration as described in Alternative 2. Further, rotary-kiln incineration has been thoroughly tested and has a well-documented history of successful performance at sites with explosives compounds in soils. Selected Alternative 3 is an innovative application of an existing technology, and site-specific treatability studies have been completed. A final optimization study is nearing completion and will allow implementation of the remedy in about 1 year. The equipment and materials required to implement Alternative 3 are readily available from local sources and national vendors.

Cost. The estimated capital, O&M, and present worth costs for each remedial alternative are as follows:

- Alternative 1
  - Capital: $0
  - O&M: $0
  - Present Worth: $0

- Alternative 2
  (Excavation to background levels)
  - Capital: $1,200,000
  - O&M: $12,800,000
  - Present Worth: $12,800,000

- Alternative 2
  (Excavation to TNT and RDX concentrations of 30 ppm)
  - Capital: $650,000
  - O&M: $3,800,000
  - Present Worth: $4,120,000

- Alternative 3 (using windrows)
  (Excavation to TNT and RDX concentrations of 30 ppm)
  - Capital: $880,000
  - O&M: $1,084,000
  - Present Worth: $1,870,000

2.8.3 Modifying Criteria

State acceptance. The State of Oregon concurs with the Army and EPA in the selection of Alternative 3 and excavation criteria of 30 ppm TNT and RDX. In addition, the state is satisfied that the state's remedial action process was followed in evaluating remedial action alternatives for the Explosives Washout Lagoons Soils Operable Unit.

Public acceptance. Based on the absence of any negative comments from the public and the support given in the single formal comment received, the public supports the selection of Alternative 3.

2.9 SELECTED REMEDY

The selected remedy to clean up the soil contamination associated with the UMDA Explosives Washout Lagoons is Alternative 3: Excavation, Composting, and Onsite Disposal, using excavation and treatment criteria of 30 ppm each of TNT and RDX and windrow composting. The treated soils will be backfilled into the excavation, covered with clean soil, and revegetated. This alternative was selected because it is protective, feasible, and cost-effective.

The selected treatment technology is bioremediation via composting. It is an innovative application of a proven technology, backed by site-specific treatability studies. Approximately one year will be required for site development and necessary procurements, with an actual composting period estimated at one additional year. The estimated present worth cost of Alternative 3 is $1,870,000. The estimated volume of soil to be removed and treated is 4,800 cy.

The major components of the selected remedy include the following:

- Construction of a roadway between the lagoons and the composting facility to transport excavated and treated soils

- Development of the composting facility onsite, including clearing and grubbing, grading, and construction of asphalt pads and erection of greenhouse-type structures

- Excavation of soils exceeding TNT or RDX concentrations of 30 ppm; excavation will include appropriate hazards monitoring and dust controls

- Mixing contaminated soils with organic amendments (e.g., vegetable waste, straw, manure) as appropriate and forming the mixture into windrows

- Regularly turning the windrows with a windrow machine

- Testing the finished compost for explosives

- Backfilling the excavation with compost, covering with approximately 2 feet of clean soil obtained from either onsite or offsite, grading, and revegetating

Alternative 3 will attain the following remediation goals:

- Soils will be excavated to the cleanup criteria of 30 ppm each of TNT and RDX. For the soils that remain in place (i.e., those soils below the excavation depth), this corresponds to attainment of a 7×10^{-6} carcinogenic risk level. This includes a contribution of 3×10^{-6} from 2,4-DNT at an average concentration of 1 ppm.

- Excavated soils will be treated to the cleanup criteria of 30 ppm each of TNT and RDX. This corresponds to attainment of a total 7×10^{-6} carcinogenic risk level. This includes an assumed contribution of 3×10^{-6} from 2,4-DNT at an average concentration of 1 ppm. (2,4-DNT has not been detected in the upper 6 to 8 feet of soil, so this contribution is conservative.)

2.10 STATUTORY DETERMINATIONS

The selected remedy satisfies the requirements under Section 121 of CERCLA to:

- Protect human health and the environment
- Comply with ARARs
- Be cost-effective
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment as a principal element

2.10.1 Protection of Human Health and the Environment

The selected remedy, Alternative 3, will reduce risks posed to future users of the Explosives Washout Lagoons site through treatment of excavated soils via composting, followed by onsite disposal of the treated soils and provision of a 2-foot cover of clean soil. The overlying clean soil cover will minimize direct contact with treated soils containing residual explosives. In the event that there is contact with the underlying treated soil, the explosives will have been degraded and immobilized, with the following residual risks:

- Human health risks associated with exposure to carcinogens in the treated soil and in soil that remains in place (i.e., soil below the excavation depth) will be reduced to within the NCP's acceptable range of 1×10^{-4} to 1×10^{-6} (both industrial and residential use scenarios).

- No adverse noncarcinogenic health effects are anticipated, considering the residual explosives concentrations in the treated soil and the conservatism incorporated into the HI calculations. For each of the explosives except TNB, the HIs associated with the treated soil concentrations will be less than 1 (industrial use scenario). The HI for TNB could be as high as 7, assuming no credit for degradation via composting. (By analogy to other explosives evaluated during the pilot studies, substantial degradation is expected, but the degree has not been quantified.) However, the uncertainty factor for TNB is 10,000, three orders of magnitude greater than the HI. Considering this uncertainty as required by the NCP, no adverse noncarcinogenic health effects are expected.

- Environmental protection is achieved by reducing explosives concentrations and associated plant stress significantly and providing a clean soil layer to support a vegetative cover.

- This remedy is expected to be consistent with future remediation of the groundwater. It provides a substantial reduction in near-surface soil concentrations and a cover of clean soil. In combination with the low precipitation and high evaporation rates in the region, negligible leaching of residual contaminants is expected.

No unacceptable short-term risks or cross-media impacts will be caused by implementation of Alternative 3. During remediation, adequate protection will be provided to the community and the environment by controlling dust generated during materials handling operations. In addition, workers will be provided with personal protective equipment and air monitoring during all phases of remediation.

2.10.2 Compliance With ARARs

The discussion below addresses compliance of the selected remedy with chemical-specific, location-specific, and action-specific ARARs.

Chemical-Specific ARARs. Under RCRA (40 CFR 261), wastewater treatment sludge from the manufacturing and processing of explosives is considered a listed waste due to explosive reactivity and is assigned EPA Hazardous Waste Number K044. Red/pink water from TNT operations is also considered a listed waste due to explosive reactivity and is assigned EPA Hazardous Waste Number K047. However, EPA's background listing document supporting these designations explicitly lists wastes derived from the manufacturing, loading, assembling, and packing of explosives, not removal from munitions. Therefore, neither the wastewater discharged to the lagoons nor the contaminated soil are specific listed wastes, and RCRA and its associated regulations are not applicable. Furthermore, although the soil contains constituents similar to those found in the listed wastes, explosives concentrations in the soil are well below the minimum concentrations necessary for explosive reactivity, the sole characteristic for which the K044 and K047 wastes were listed. Therefore, while the RCRA listings might be relevant to the contaminated soil, they are not appropriate since the soil does not exhibit the characteristic of concern.

At present, there are no chemical-specific federal or state regulations that specify action or cleanup levels for explosives contaminants in soil.

The state has implemented the Oregon Environmental Cleanup Rules (OAR 340-122), which specify generic cleanup standards and which the state has determined are ARARs for the UMDA Explosives Washout Lagoons. In summary, the regulations state that in the event of a release of a hazardous substance, cleanup shall be to background or, if that is not feasible, to the lowest level that is protective and feasible. A cleanup-to-background scenario was evaluated under Alternative 2 but determined not to be feasible based on a cost seven times greater than other scenarios that provided adequate protection. A cost-benefit analysis of remediation options was then conducted, resulting in the selection of Alternative 3 as the remedy achieving the lowest levels that are protective and feasible (see Section 2.10.3).

Location-Specific ARARs. No location-specific ARARs are identified for this alternative. Although areas of the UMDA installation provide critical habitat for threatened or endangered species, no activities at the Explosives Washout lagoons are expected to impact those habitats.

Action-Specific ARARs. The treatment and disposal of the contaminated soil and compost will comply with the relevant and appropriate sections of the Oregon Solid Waste Management Regulations (OAR 340-61-050). These include provisions for drainage control, odor control, and fire protection at composting facilities, and preparation of a plan describing the final disposition of the compost.

2.10.3 Cost-Effectiveness

The selected remedy provides overall effectiveness proportionate to its costs. Alternative 3 provides 97-99 percent contaminant reduction at a cost of $1.9 million. Alternative 3 is somewhat more protective, providing 99.9 percent contaminant reduction, but at a cost of $4.1 million. Therefore, Alternative 2 is not cost-effective, since its incremental increase in cost is disproportionate to its incremental increase in protection.

2.10.4 Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

The selected remedy is a permanent solution that provides the best balance of trade-offs among the alternatives. Alternative 1 fails to meet the threshold criteria of overall protection and compliance with ARARs and is thus clearly unacceptable. Both Alternatives 2 and 3 meet the threshold criteria. They are also both comparable in terms of short-term effectiveness and implementability. They differ in terms of degree of protectiveness afforded and cost. Alternative 2 provides the greatest degree of protection, reducing explosives concentrations by an estimated >99.99 percent, versus 97 to >99 percent for Alternative 3. While this makes Alternative 2 the best in terms of long-term effectiveness and reduction of toxicity, Alternative 3 achieves acceptable protection levels and satisfies those criteria adequately, at half the cost. In addition, it provides a demonstration of an innovative technology.

The support of the state and community in the evaluation process and the selection of Alternative 3 further justify the selection of Alternative 3.

The selected remedy meets the statutory requirement to utilize permanent solutions and alternative treatment technologies to the maximum extent practicable.

2.10.5 Preference for Treatment as a Principal Element

The statutory preference for treatment is satisfied by using biological treatment via composting as the primary means for addressing and degrading the explosives contaminants.

2.11 DOCUMENTATION OF SIGNIFICANT CHANGES

The selected remedy was the preferred alternative presented in the Proposed Plan. No changes have been made.

SECTION 3

RESPONSIVENESS SUMMARY

The final component of the ROD is the Responsiveness Summary, which serves two purposes. First, it provides the agency decision makers with information about community preferences regarding the remedial alternatives and general concerns about the site. Second, it demonstrates to members of the public how their comments were taken into account as a part of the decision-making process.

Historically, community interest in the UMDA installation has centered on the impacts of installation operations on the local economy. Interest in the environmental impacts of UMDA activities has typically been low. Only the proposed chemical demilitarization program, which is separate from CERCLA remediation programs, has drawn substantial comment and concern.

As part of the installation's community relations program, the UMDA command assembled in 1988 a TRC composed of elected and appointed officials and other interested citizens from the surrounding communities. Quarterly meetings provide an opportunity for UMDA to brief the TRC on installation environmental restoration projects and to solicit input from the TRC. Two TRC meetings were held during preparation of the supplemental investigation and feasibility study for the Explosives Washout Lagoons Soils Operable Unit, one on October 15, 1991, and the other on February 19, 1992. In those meetings, the TRC was briefed on the scope and results of the supplemental investigation and the methodology of and remedial alternatives considered in the feasibility study. The response received from the TRC was positive; the members showed particular interest in and support for the composting alternative.

Notice of the public comment period, public meeting, and availability of the Proposed Plan was published in the *Hermiston Herald*, the *Tri-City Herald*, and the *East Oregonian* in April 1992.

The Feasibility Study and Proposed Plan for the Explosives Washout Lagoons Soils Operable Unit were released to the public on April 27, 1992. The public comment period started on that date and ended on May 27, 1992. The documents constituting the administrative record were made available to the public at the following locations: UMDA Building 1, Hermiston, Oregon; the Hermiston Public Library, Hermiston, Oregon; and the EPA office in Portland, Oregon.

A public meeting was held at Armand Larive Junior High School, Hermiston, Oregon, on May 5, 1992, to inform the public of the preferred alternative and to seek public comments. At this meeting, representatives from UMDA, USATHAMA, EPA, ODEQ, and CH2M HILL presented the proposed remedy. Approximately 20 persons from the public and media attended the meeting. Questions asked during the informal question and answer period requested more detail regarding excavation criteria, the treatability studies, implementation methods, and costs associated with composting.

Only one formal comment was received during the public meeting. The speaker was a former UMDA employee and current community leader. He stated that after reading the Proposed Plan and listening to the presentations, he thought the community could be assured that the Army was interested in protecting the environment and the people living there. No response was required.

No other comments, either verbal or written, were received by UMDA, EPA, or ODEQ during the public comment period.

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APPENDIX

To be provided by the State of Oregon